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# NOTCHED-BAR IMPACT TESTING OF URANIUM

By
S. J. Paprocki
H. A. Saller



June 26, 1952

Battelle Memorial Institute
Columbus, Ohio

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# NOTCHED-BAR IMPACT TESTING OF URANIUM

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## ABSTRACT

This report describes the behavior of uranium metal in notched-bar impact tests. The metal was tested over a range of temperatures from -100 F to 300 F. Its behavior was comparable with hot-rolled Monel or Inconel. No sharp-transition temperature was noted, and ductile fractures were obtained at all test temperatures.

BATTELLE MEMORIAL INSTITUTE
505 King Avenue
Columbus 1, Ohio

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## INTRODUCTION

The impact strength of a metal is most frequently determined by measuring the dynamic resistance to rupture of a notched specimen. Past experience indicates that such values are not easily related to other established mechanical properties. Metals with apparently identical mechanical properties often exhibit a marked difference in ability to resist impact.

A factor of considerable importance which needs to be kept in mind when evaluating impact data is that the values obtained under certain test conditions are not ultimate measures of impact toughness. They are merely indications of the resistance to impact of the particular metal tested under those specific test conditions. The geometry of the specimens, past heat treatment, and rate of straining strongly influence the results.

The individual values of energy to rupture obtained from an impact test are usually of no significant importance. Over a range of properly selected test temperatures, many of the metals exhibit a transition from a ductile-to-brittle failure. In most instances, this transitory change occurs around room temperature and is detected by a pronounced change in the energy required to produce rupture. It is this embrittlement phenomenon that is significant.

Distinct from the test conditions which influence the impact data, there is also a difference in response of various metals to any given set of test conditions. It has been shown, however, that by standardization of test conditions a comparative susceptibility to embrittlement for different metals can be evaluated from the test data.

This report describes the manner of behavior of uranium metal when subjected to impact testing. The purpose of this investigation was the determination of the susceptibility of uranium metal to embrittle as compared with other metals.

## TEST CONDITIONS

Opinion seems to be divided concerning what constitutes standard impact-test conditions. There has been a growing tendency to use the ASTM standard Charpy specimen with either the keyhole or V notch. The V notch is usually preferred for the comparative plastic metals where a keyhole notch may not introduce stress raisers of sufficient magnitude to give a clean

rupture. Several different test machines are employed. Generally, the machines operate with a striking velocity of 12 to 18 feet per second at a capacity of from 70 to 220 foot-pounds. For this work, the standard Charpy specimen with an Izod V notch and an Amsler test machine with an initial-energy load of 93 foot-pounds were selected.

The test covered a temperature range of from +300 to -100 F. This range of test temperatures was selected arbitrarily with the knowledge that for most metals the transition from a ductile-to-brittle failure occurs within this temperature spread. The test temperatures were obtained by use of both a mineral oil and dry ice-acetone bath. Each of the test specimens was soaked for 15 minutes at temperature and tested within ten seconds after removal from the bath. Trial runs on dummy specimens with attached thermocouples indicated that a maximum temperature variation of two degrees Fahrenheit from the test temperature occurs during this ten-second set-up period.

## TEST MATERIAL

There is little need to emphasize the effects of heat treatment on anisotropic metals such as uranium. It is sufficient to state that the same metal with different heat treatments may possess a wide range of mechanical properties.

This investigation was conducted with uranium specimens possessing five different treatment histories, namely: as cast; alpha rolled; alpha rolled, beta quenched; alpha rolled, beta quenched, and alpha annealed; and alpha rolled, gamma annealed. Conditions relative to each heat treatment are listed in Table 1.

## TEST RESULTS

The test results are summarized in Figures 1 to 5. It is interesting to note that the heat treatment of uranium does not appreciably influence its ability to resist impact.

No abrupt transition temperature was observed. Plastic deformation in the form of midbuckling was prevalent at all test temperatures. (Figures 6 to 10). A considerable scatter of impact values was noted for the cast and gamma-annealed material. The coarse inherent structure of

TABLE 1. HEAT-TREATMENT CONDITIONS FOR URANIUM METAL

| Heat Treatment | Fabrication | Conditions of Treatment |
|---|---|---|
| Alpha rolled | Rolled at 550 C | Air cooled. |
| Beta quenched | Ditto | Quenched from 725 C into brine solution. |
| Beta quenched, alpha annealed | " | Quenched from 725 C into brine solution, followed by an anneal at 550 C. |
| Gamma annealed | " | Furnace cooled from 850 C. |

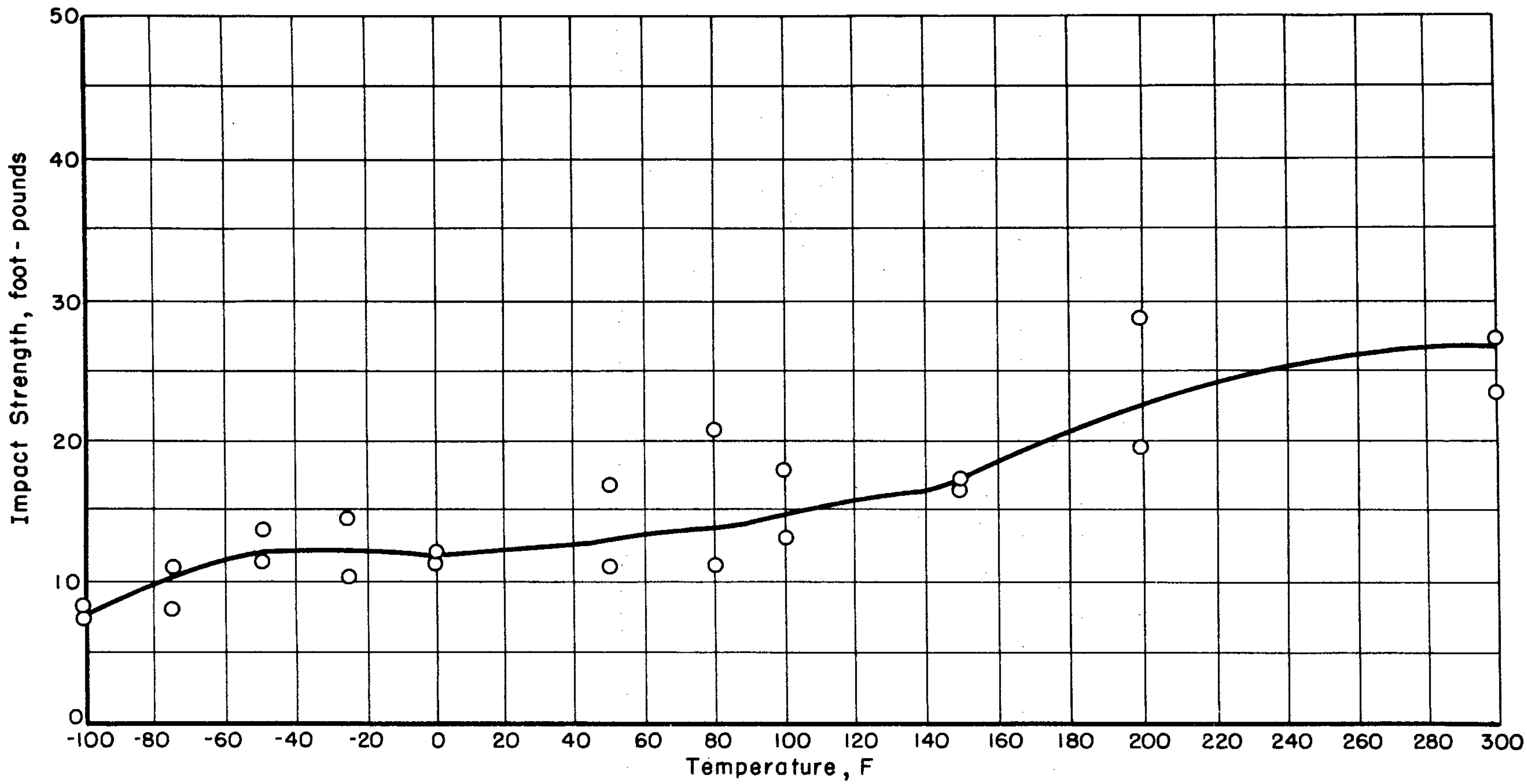



FIGURE I. LOW-TEMPERATURE IMPACT STRENGTH OF URANIUM (AS CAST)

C-2263

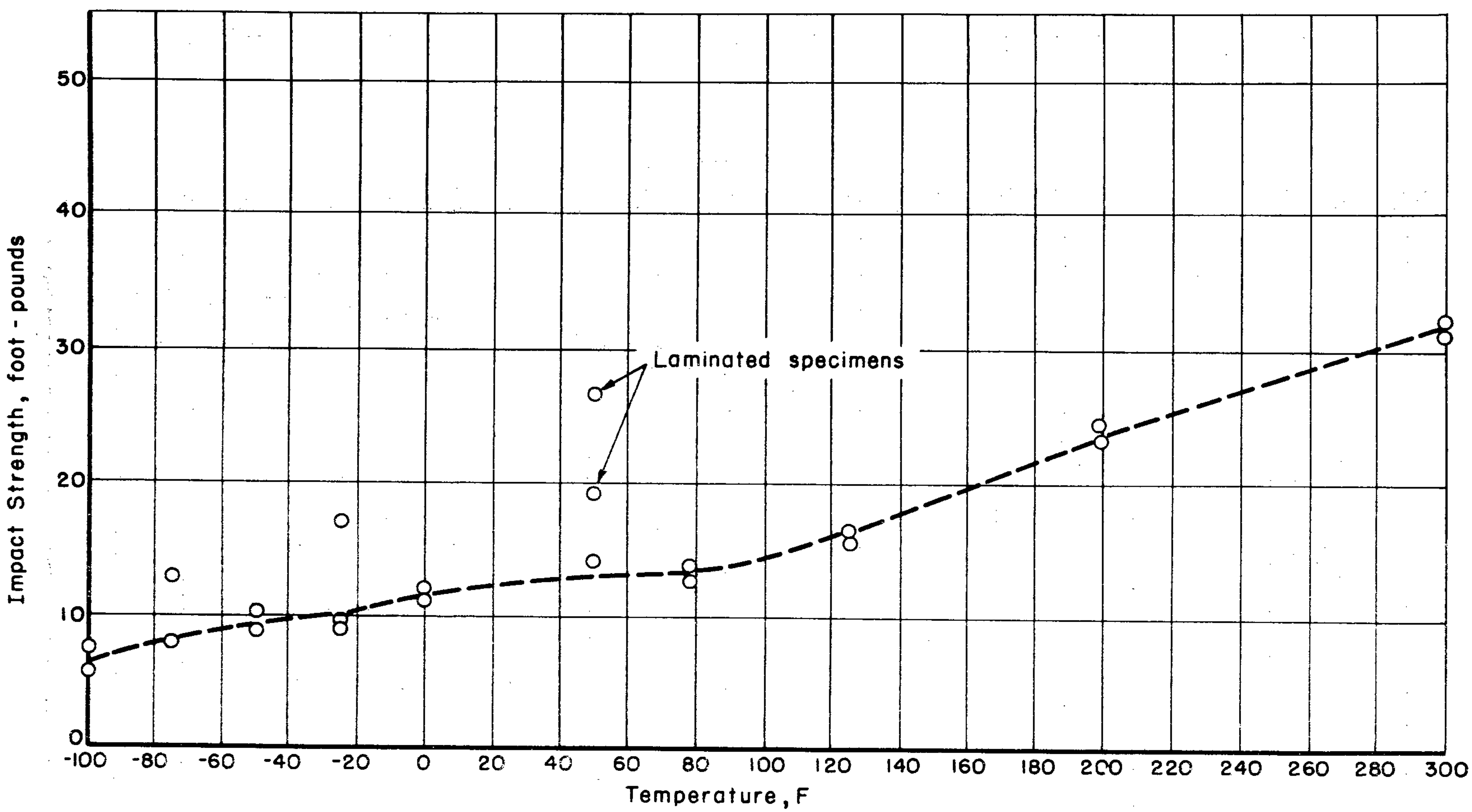



FIGURE 2. LOW-TEMPERATURE IMPACT STRENGTH OF URANIUM (ALPHA ROLLED)
C-2264

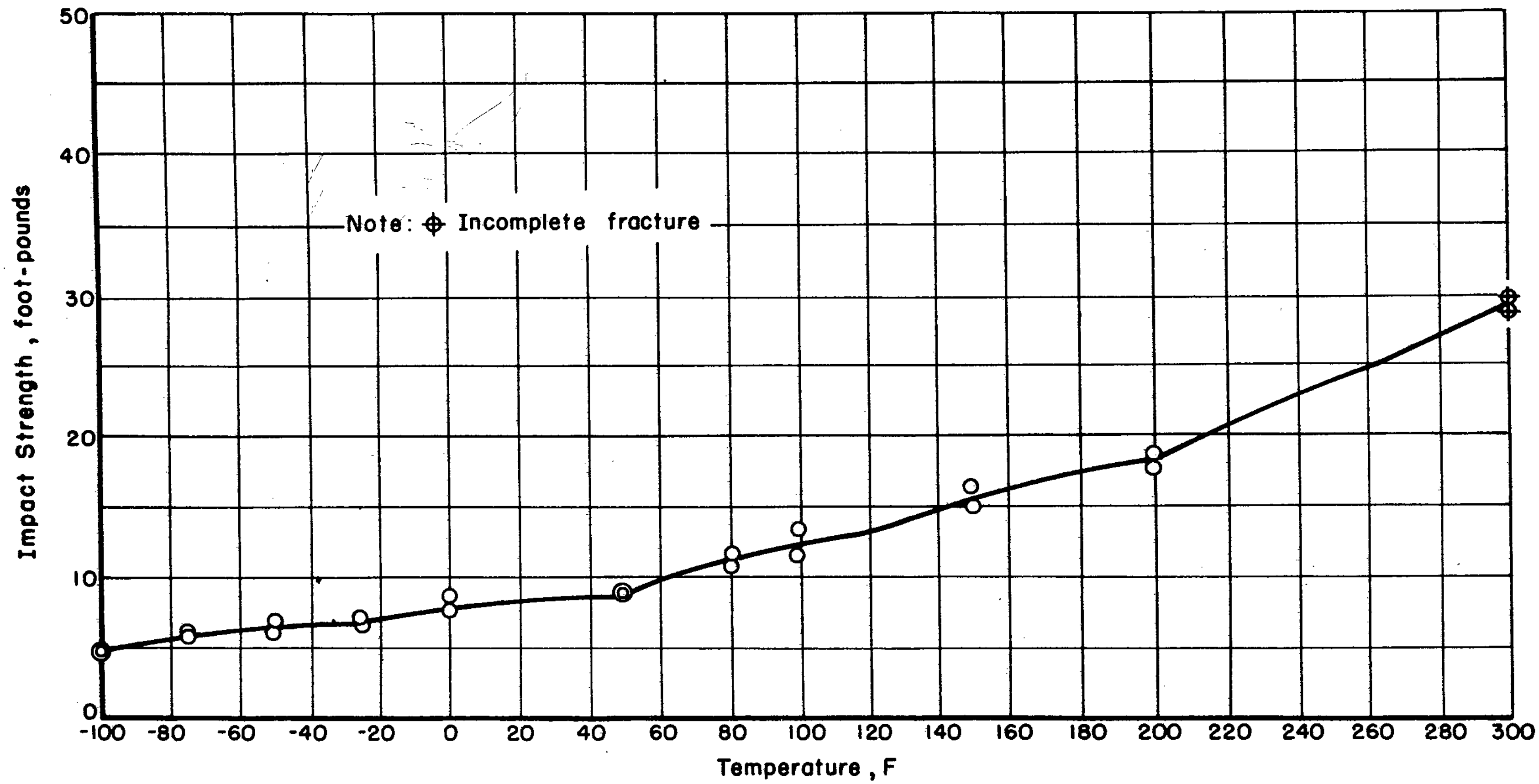



FIGURE 3. LOW-TEMPERATURE IMPACT STRENGTH OF URANIUM (BETA QUENCHED)

C-2265

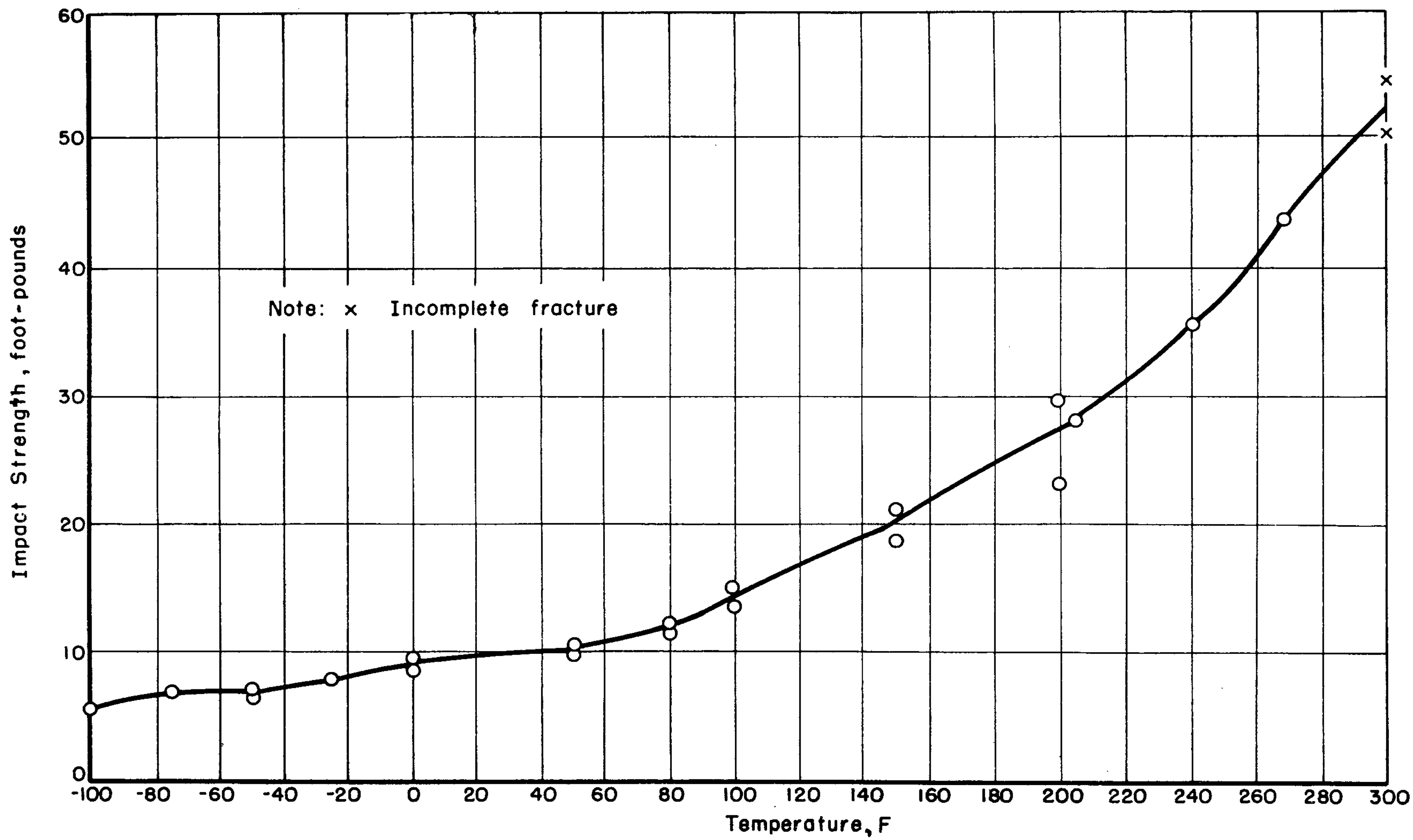



FIGURE 4. LOW-TEMPERATURE IMPACT STRENGTH OF URANIUM (BETA QUENCHED, ALPHA ANNEALED)
C-2266

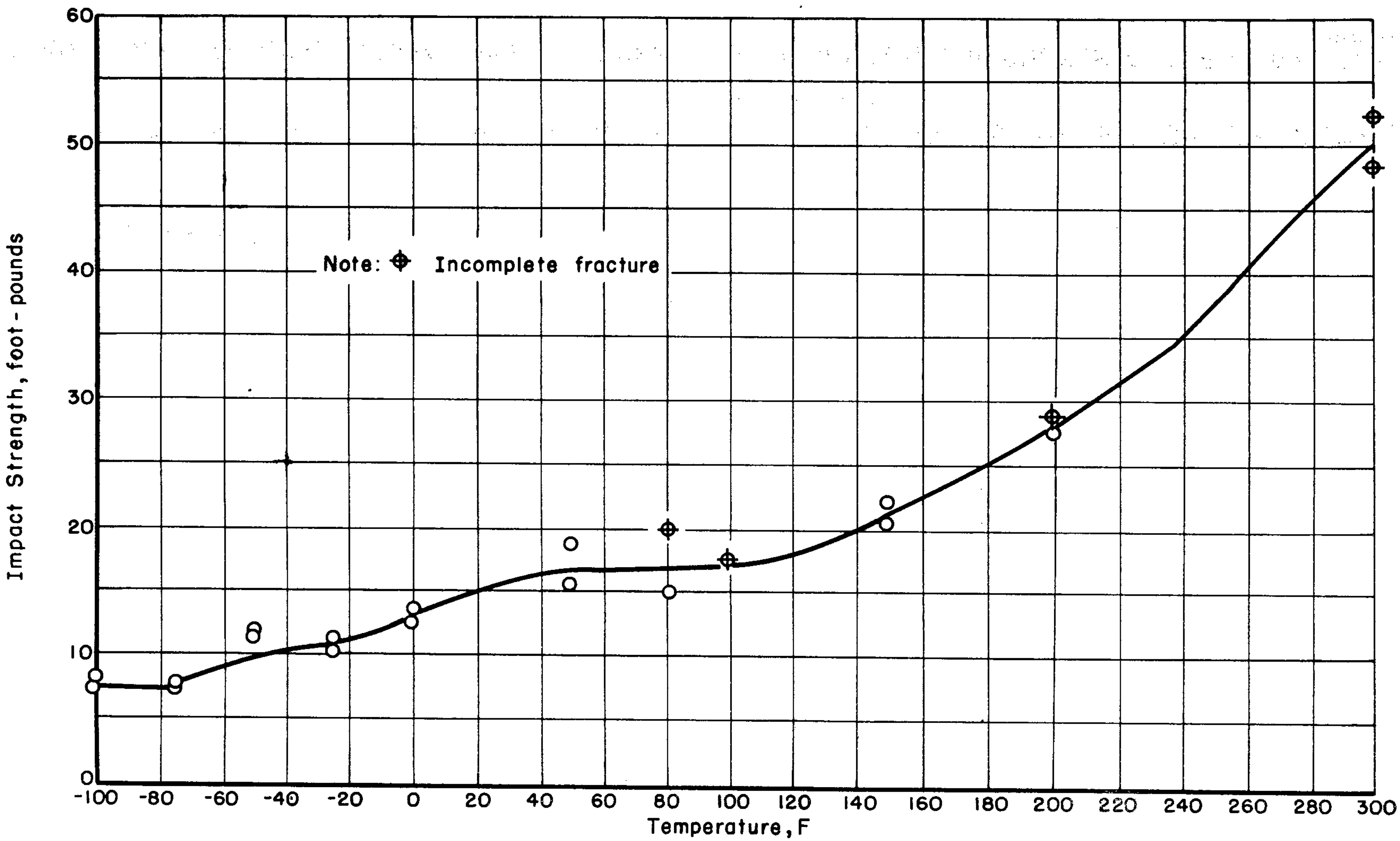



FIGURE 5. LOW-TEMPERATURE IMPACT STRENGTH OF URANIUM (GAMMA ANNEALED)

C-2267

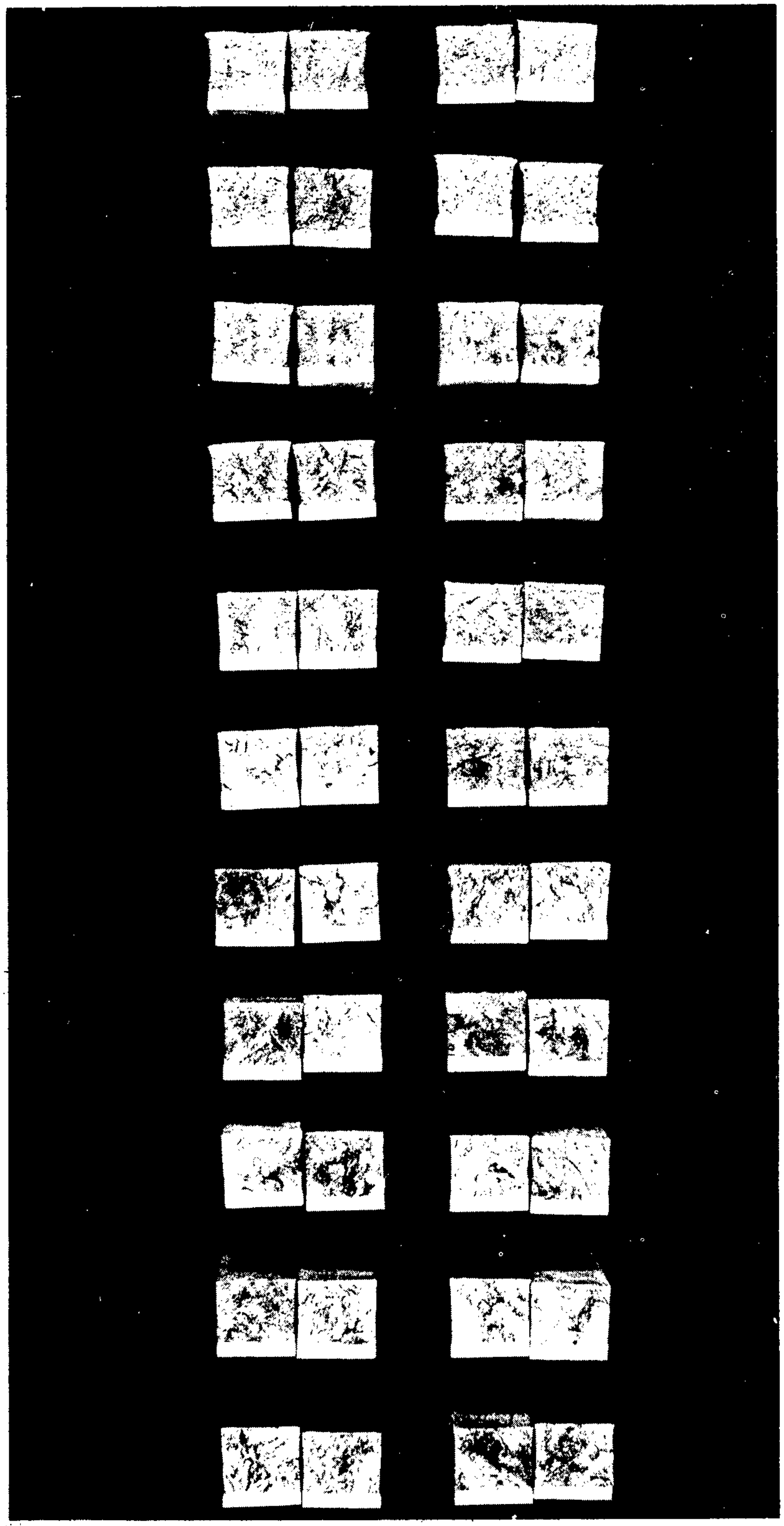
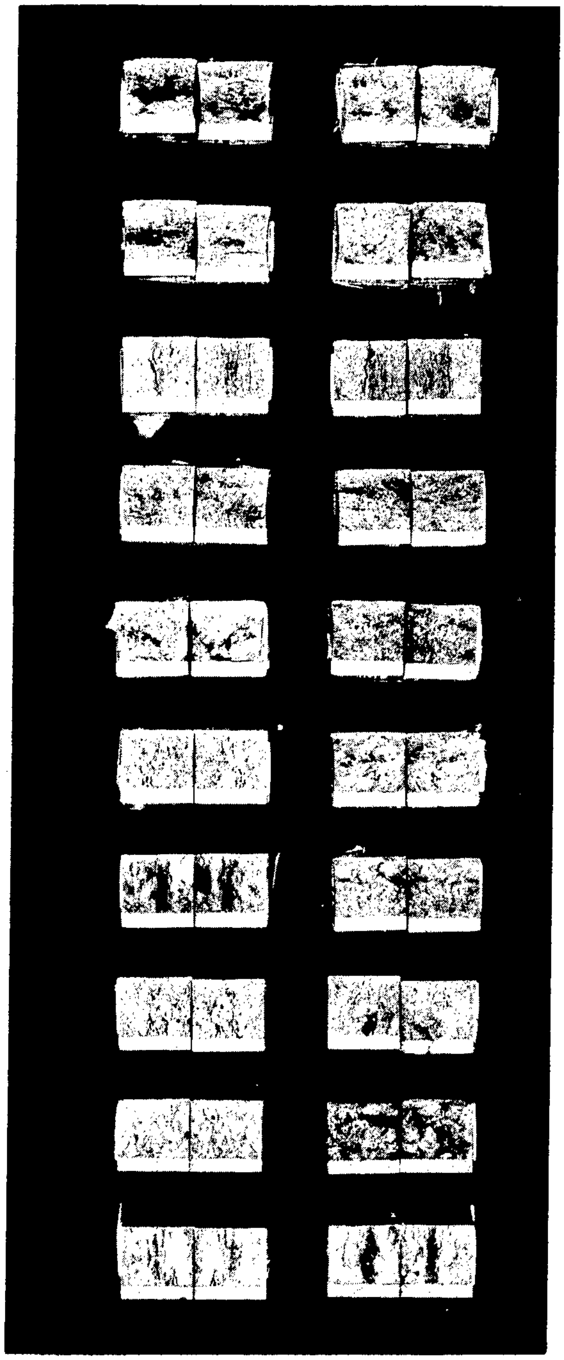



FIGURE 6. CHARPY IMPACT SPECIMENS (AS CAST)

Test Temperature, F



300

200

125

80 (Room)

50

0

-25

-50

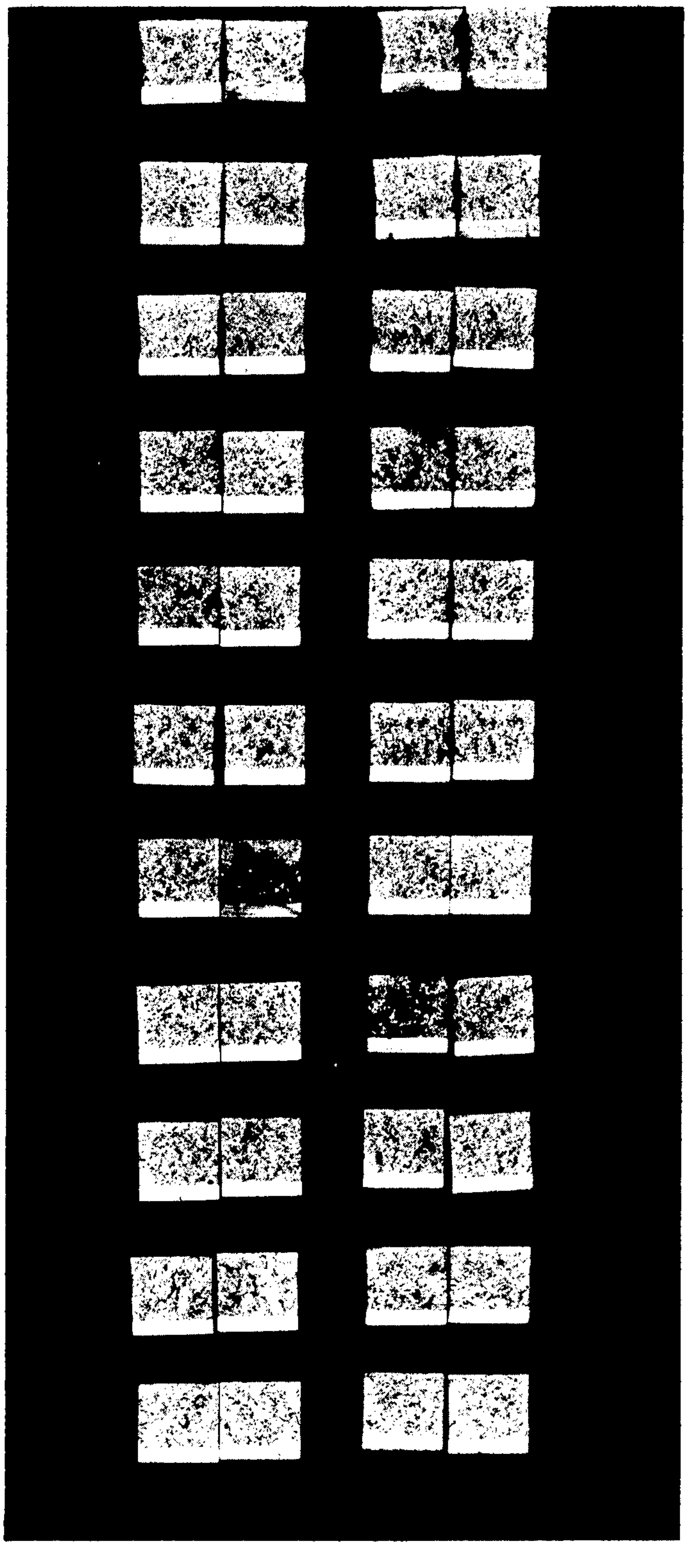
-75

-100

55259

FIGURE 7. CHARPY IMPACT SPECIMENS (ALPHA ROLLED)

Test Temperature, F



300

200

150

100

80 (Room)

50

0

-25

-50

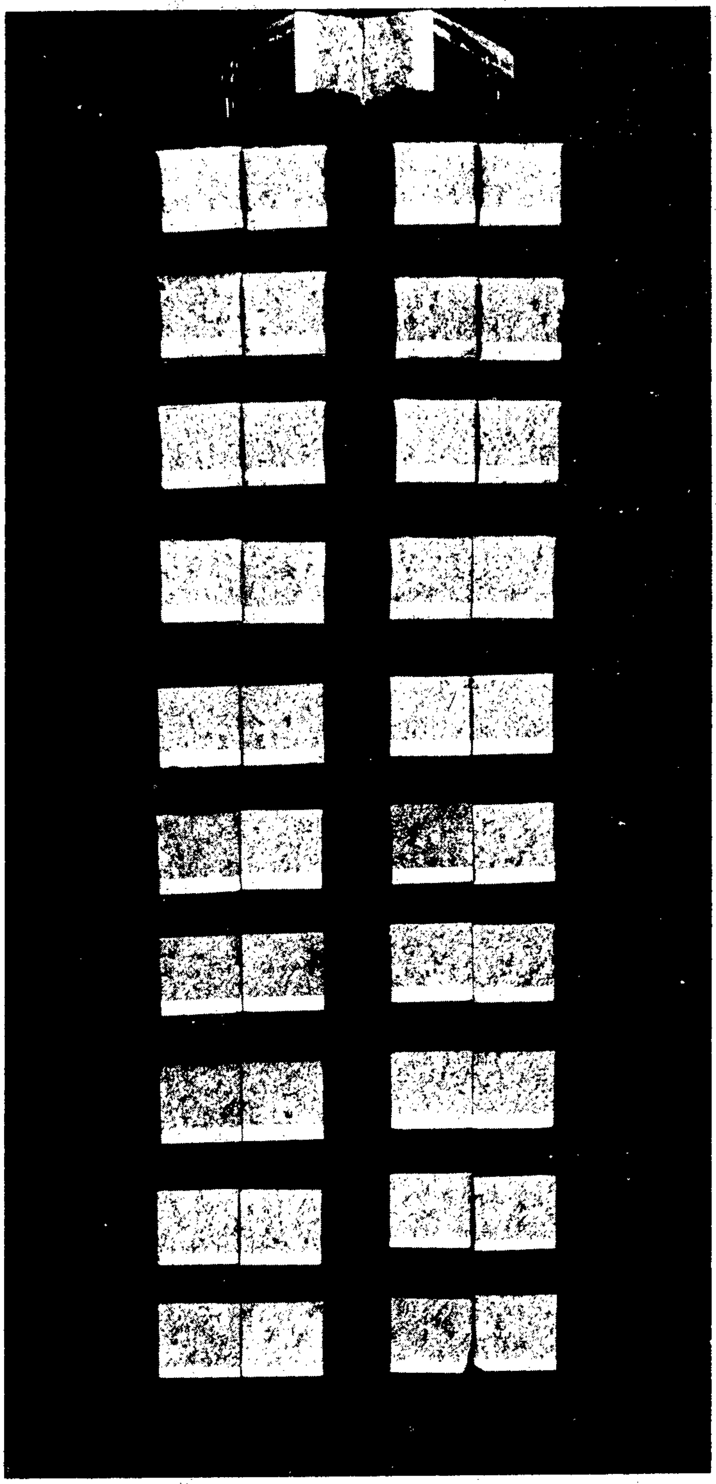
-75

-100

57608

FIGURE 8. CHARPY IMPACT SPECIMENS (BETA QUENCHED)

Test Temperature, F



300

200

150

100

80 (Room)

-50

0

-25

-50

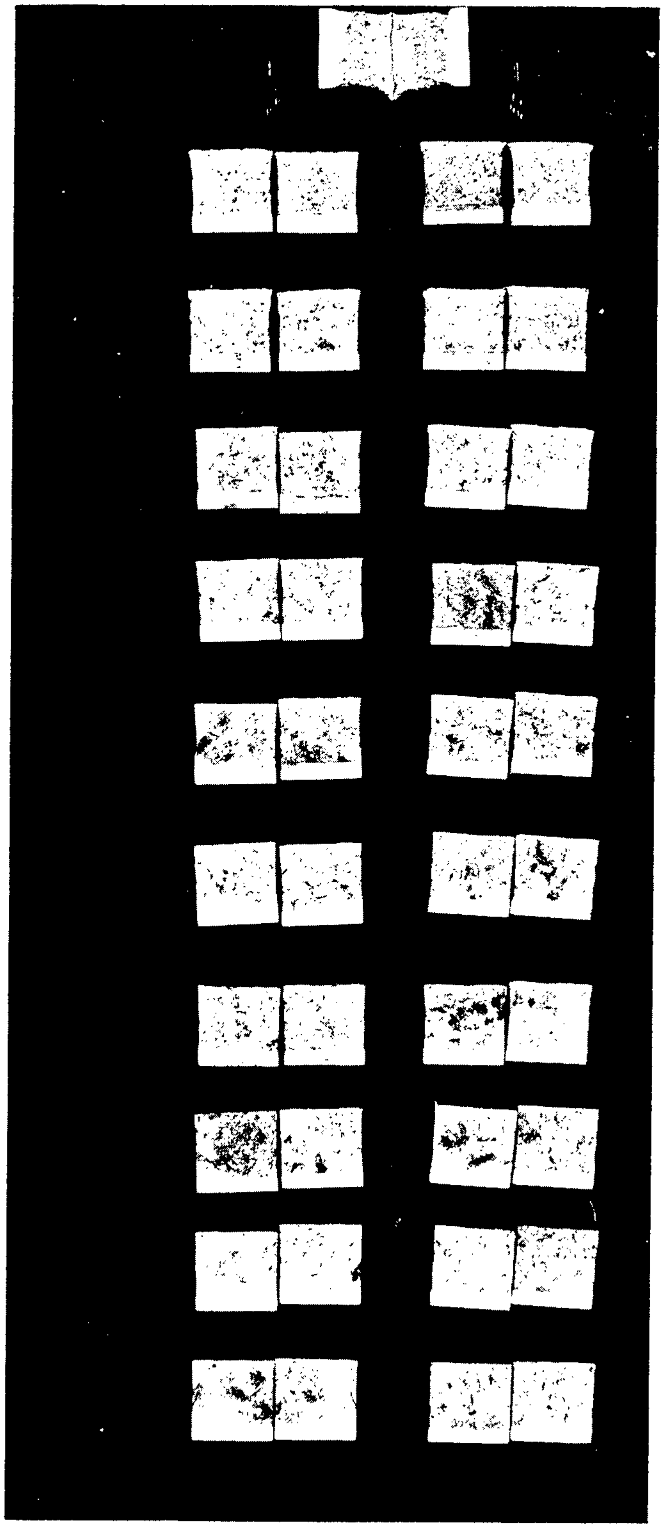
-75

-100

57607

FIGURE 9. CHARPY IMPACT SPECIMENS (BETA QUENCHED, ALPHA ANNEALED)

Test Temperature, F



300

200

150

100

80 (Room)

50

0

-25

-50

-75

-100

57609

FIGURE 10. CHARPY IMPACT SPECIMENS (GAMMA ANNEALED)

both these materials is believed to be the cause of the inconsistent behavior. This was more pronounced for the cast series where cast defects were probably present.

For comparative purpose, the ability of uranium metal to resist impact can best be compared with that of hot-rolled Monel or Inconel. Its impact toughness at the subnormal temperatures was not much different than at room temperature.